Structured Educational Program about Artificial Pancreas for Patients with Type 1 Diabetes Mellitus

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Abstract

Background: Artificial pancreases are medical devices designed to help patients with type 1diabetes manage blood sugar levels by monitoring glucose automatically and delivering insulin as needed. Educational programs help patients understand how to use artificial pancreases effectively, ensuring safety, confidence, and long-term success in diabetes management. **Aim:** To evaluate the effect of a structured educational program about artificial pancreas for patients with type 1 diabetes mellitus. **Research Design**: A quasi-experimental design was used. **Setting**: The study was conducted at outpatient clinic of diabetes in the National Diabetes and Endocrinology Institute affiliated to General Authority for Hospitals and Educational Institute, Cairo, Egypt. **Sampling**: A purposive sample was used. **Sample size:** 274 patients used an artificial pancreas. **Tools:** Three tools were used for data collection, **Tool I:** A structured interviewing questionnaire, which covers two parts: **Part 1**: Socio-demographic characteristics of patients and medical history for diabetic patients. **Part 2:** Patients' knowledge about artificial pancreas. **Tool II:** Patients' reported practices regarding dealing with artificial pancreas. **Tool III:** Patients' attitude toward artificial pancreas **Results:** 74.5% of the studied patients had poor knowledge, 76.6% of them had inadequate reported practices, and 83.9% of them had a negative attitude about artificial pancreas at pre-program. However, their highly statistically significant improvements were detected after the implementation of a structured educational program in good knowledge= 82.7%, adequate reported practices= 84.7% and positive attitude= 88.0%. **Conclusion:** The structured educational program about artificial pancreas improved patients' knowledge, reported practices and attitude post-program than pre-program. **Recommendation**: Simple pamphlets and posters about artificial pancreas should be provided for diabetic patients in outpatient clinics.

Key Words: Artificial Pancreas, Structured Educational Program, Type 1 Diabetes Mellitus.

Introduction:

Type 1 Diabetes Mellitus (T1DM) is a chronic autoimmune disorder characterized by the devastation of insulin-producing beta cells in the pancreas, leading to insufficient insulin secretion. The condition requires lifelong management through exogenous insulin therapy, typically administered via injections or insulin pumps. However, the challenge in achieving tight glucose control due to the need for frequent monitoring and manual adjustment of insulin dosage remains a key barrier to optimal disease management ***(Visser et al., 2023).***

Artificial Pancreas (AP) therapy is an emerging treatment option that combines an insulin pump and a continuous glucose monitor with a control algorithm to deliver insulin in a glucose-responsive manner (i.e., a single-hormone artificial pancreas system). Therefore, the use of an artificial pancreas aims to reduce the burden of constant monitoring and provide more stable blood glucose levels, which in turn helps to minimize the risk of acute and long-term complications associated with diabetes. This advanced option has led to the creation of fully automated systems that are capable of adjusting insulin doses in real time, improving both the life and health outcomes for individuals with T1DM ***(Munachiso and Roman, 2023).***

There are different configurations of the AP, including hybrid and fully closed-loop systems. In hybrid systems, the insulin pump delivers basal insulin autonomously based on Continuous Glucose Monitoring (CGM) data, while the user must still administer bolus doses

for meals. Fully closed-loop systems, however, automate both basal and bolus insulin delivery, offering a truly artificial pancreas experience. Both systems aim to reduce the patient's need for constant management, but the wholly closed-loop system holds the promise of a more hands-free approach ***(Akturk et al., 2022).***

The CGM continuously measures glucose levels in real-time and transmits the data to a control algorithm housed in a smartphone, insulin pump, or dedicated device. This algorithm analyzes the glucose trends and determines the precise amount of insulin needed. The insulin pump then delivers the appropriate insulin dose through a small catheter inserted under the skin ***(Zhao et al., 2025).*** Many advantages for artificial pancreas as improved blood sugar control, it continuous monitors glucose monitoring and automatic insulin delivery, reducing fluctuations, maintaining glucose within a healthy range and enhancing quality of life by minimizing the burden of frequent glucose monitoring, insulin injections, and manual dose calculations ***(Oser et al., 2025).***

The impact of AP on glycemic control is profound. Studies have demonstrated that AP systems significantly improve hemoglobin A1C (HbA1c levels) while reducing the occurrence of severe hypoglycemia. Additionally, patients using AP devices experience improved quality of life due to the automation of insulin management and a reduction in the mental load associated with frequent blood glucose monitoring ***(Bergenstal et al., 2023).***

One major challenge is cost; these systems are expensive and may not be covered by all insurance providers, making them inaccessible to many patients. While, the technology reduces the requirement for manual insulin management, it is not completely autonomous users must still calibrate sensors, replace infusion sets, and respond to alerts. Device accuracy and reliability pose concerns, as errors in CGM readings or insulin pump malfunctions can lead to incorrect insulin delivery, increasing the risk of hypoglycemia or hyperglycemia. Technical issues as sensor failures, connectivity problems or delays in insulin absorption affect performance ***(Kovatchev et al., 2024).***

Despite its potential, the adoption of AP technology remains slow due to various barriers as cost, accessibility, and a lack of awareness among patients and healthcare providers. Furthermore, understanding the intricate nature of the technology and its benefits requires thorough education. Healthcare professionals, particularly nurses, play a critical role in this process. Nurses are frequently the first point of contact for patients and are crucial in facilitating the understanding and acceptance of AP technology ***(Blauw et al., 2024).***

A Structured Educational Program (SEP) aims to educate and support patients with type 1 diabetes in understanding and effectively using the artificial pancreas system. This structured program provides personalized training sessions led by a multidisciplinary team, including endocrinologists, diabetes educators, nurses, and dietitians, to ensure patients and caregivers are well-prepared for this advanced technology. The program covers essential topics as how the artificial pancreas works device setup and calibration, troubleshooting common issues, and interpreting glucose data. Patients receive guidance on dietary management, insulin adjustments, and lifestyle modifications to optimize blood sugar control ***(Aaron et al., 2024).***

Nurses play a vital role in helping patients use artificial pancreas, troubleshooting, and integrating them into daily routines. Their ability to demonstrate practical aspects such as the setting of insulin parameters and interpreting data from CGMs and insulin pumps is critical in empowering patients with T1DM to effectively manage their condition. Furthermore, nurses are well-positioned to offer support to patients navigating the complexities of adapting to new technologies ***(Ernawati et al., 2023).***

Significance of the study: -

Artificial pancreas systems are used for managing Type 1 Diabetes (T1D). Globally, it is estimated that around 8.4 million people were living with type 1diabetes in 2021, and this number is projected to rise to 17.4 million by 2040. The condition is most commonly diagnosed in children and adolescents, though it

can occur at any age. Countries with over rates of T1D include those in Northern Europe and North America, with Finland having the highest incidence globally. **In Egypt**, year 2023 people with type 1diabetes in all age groups were 191,776.0 patients (***Rooney et al., 2023).***

The artificial pancreas system operates in real-time by using continuous glucose sensors to monitor glucose levels and then adjusting insulin delivery accordingly via an insulin pump. By automating insulin therapy, the AP helps maintain tighter glycemic control compared to conventional methods, reducing the burden on patients who must frequently monitor and adjust their glucose levels. This advancement is especially critical for patients who struggle with the manual adjustment of insulin or experience frequent episodes of hypoglycemia ***(Boughton et al., 2024).***

This device offers substantial benefits in terms of reducing the risk of diabetes-related complications. By mimicking the function of a healthy pancreas, the AP system minimizes glycemic variability, which has been linked to the development of long-term complications as retinopathy, nephropathy, and neuropathy. Moreover, maintaining tighter glucose control can help prevent the acute complications of diabetes, including diabetic ketoacidosis, a potentially life-threatening condition. These improvements can significantly enhance the quality of life for patients living with T1DM by reducing hospitalizations and the need for emergency interventions ***(Wilmot et al., 2023).***

Nurses perform an essential role in the successful implementation and management of artificial pancreas systems in patients with T1DM. Their responsibilities include educating patients about the system, providing technical support, and ensuring patients can effectively use the devices. As T1DM management becomes increasingly complex with the advent of closed-loop systems, nurses act as a bridge between the patient, technology, and healthcare team. Nurses help monitor the patient's response to the device, troubleshoot issues, and make necessary adjustments in collaboration with other health care providers ***(Tauschmann et al., 2024).*** Therefore, it was important to perform a structured educational program about artificial pancreas for patients with type 1 diabetes mellitus.

Aim of the study:

The study aimed to evaluate the effect of a structured educational program about artificial pancreas for patients with type 1 diabetes mellitus through the following

- Assess the studied patients' level of knowledge, reported practices and attitude regarding artificial pancreas.
- Plan and implement a structured educational program about artificial pancreas for patients with type 1 diabetes mellitus
- Evaluate the effect of a structured educational program about artificial pancreas on the patients' knowledge, reported practices and attitude.

Research Hypothesis:

The studied patients' knowledge, reported practices and attitude will be improved after implementation of a structured educational program about artificial pancreas

Subjects and Methods:

Research Design

A quasi-experimental research design was utilized to achieve the aim of this study.

Setting

This study was conducted at the outpatient clinic of diabetes in the National Diabetes and Endocrinology Institute affiliated with the General Authority for Hospitals and Educational Institute, Cairo, Egypt. The National Diabetes and Endocrinology Institute serves as a leading center for the diagnosis, treatment, research, and prevention of endocrine and metabolic disorders, with a primary focus on diabetes mellitus. One of the institute's significant research focuses includes the development and clinical evaluation of artificial pancreas systems closed-loop insulin delivery devices that automate glucose monitoring and insulin administration in individuals with type 1diabetes. These systems, which combine CGM, insulin pumps, and advanced control algorithms, are at the forefront of personalized diabetes management.

Sample:

A purposive sample included 274 patients with type 1 diabetes who use an artificial pancreas and attended the previously mentioned sitting. The total patients with artificial pancreas follow-up in outpatients in last year were 950 and the study sample was selected according to the inclusion criteria

1- Patients diagnosed with type 1 diabetes mellitus undergoing artificial pancreas from both sexes.
2- Patients should be able to read and write.
3- Agree to participate in the study.

The sample size:

The sample size was calculated by the following equation:

$n=N\ [1+N\ (e^2)]$ **(Simon, 2023)**

n=sample size

N=population size is 950

e=0, 05 is the level of perception

n=950[1+950 (0, 0025)] =274

The actual size of the sample was 274 patients

Data collection tools:

Three tools were used for data collection.

Tool (1): Structured interviewing questionnaire: **It was designed by researchers and consists of two parts**:

Part (1): Socio-demographic characteristics and medical history of the studied patients: It divided into 2 sub items:

A- Socio-demographic characteristics contained 7 items as age, sex, marital status, level of education, occupation, family income and place of residence.

B- Medical history for diabetic patients: it included 9 closed ended questions as duration of diabetes, complication, family history and their relationship, type of medication or therapy are currently using to manage diabetes, frequency of blood sugar monitoring, used of other medication, types of mediation used and hospitalization due to diabetes-related complications in the past year.

Part (II): Studied patients' knowledge about artificial pancreas.

It was designed by the researchers after reviewing recent related literatures **Heinemann, (2022), Peters & Laffel, (2021) and Weiss, (2021). It contained 16 multiple choice questions** related to definition of type 1 diabetes mellitus, symptoms, function of pancreas, meaning of artificial pancreas, indications, mechanism of function, persons more needed for artificial pancreas, benefits and barrier faced in using artificial pancreas, different types of insulin use in artificial pancreas, complications of artificial pancreas, role of insulin pump in artificial pancreas, important of follow up for insulin pump of artificial pancreas, ways of travel care for artificial pancreas during travel, exercises and during taking shower.

Scoring system for patient knowledge:

The answers were compared with a model key answer. Each question had 3 responses; complete correct answers (2 scores), incomplete correct answers (1 score), and incorrect answers or don't know (0 score). The total knowledge scores were 32 scores for 16 questions. Knowledge answers were classified into three categories:

- Good level of knowledge if scored ≥75 % (24-32scores)
- Average level of knowledge if score from 50-<75 % (16-<24 scores)
- Poor level of knowledge if score < 50 % (<16 scores).

Tool II: Patients' reported practices regarding dealing with artificial pancreas.

It was adapted and modified by the researchers after reviewing the related literature **Battelino, (2019) Sherr, (2020), and Garg, (2021)** which assess patients reported practices regarding dealing with artificial pancreas and consist of 3 main items.

(1) General practices contained about 6 items such as perform hand washing by water and soap and dry, it before dealing with artificial pancreas, regular calibration of CGM , check for proper insulin pump functionality, regularly inspect the insulin pump to ensure proper infusion site adhesion, insulin cartridge levels and tubing integrity, appropriate target glucose range, daily inspection of the AP system to confirm that all components connected, powered, and functioning correctly and Periodically upload data from the CGM and insulin pump to a cloud-based platform or medical provider for clinical review.

(2) Insulin distribution and glucose control

include 5 items as adhering to pre-meal insulin delivery protocol, program the system to deliver insulin based on meals, allow automated adjustments for insulin delivery and monitor blood glucose reading regularly, respond to alarm -alerts and maintain a consistent routine such as mealtimes and physical activity.

(3) Device maintenance and troubleshooting consisted of 6 items as perform regular site rotation for insulin infusion, ensure correct placement of sensors and insulin infusion sites, update software and firm ware, store the insulin pump and CGM components at recommended temperatures and in a secure location to avoid malfunction or damage, take consultation from doctor in any change happen at site of sensor and insulin pump and take consultation and follow up doctor in case of disturbances of blood sugar level.

Reported practices scoring system:

Total items =17 items, each item had two responses done was scored 1 and not done was scored zero. Total scores were 0 for 17 grads. The Total scores are calculated and converted into percent scores as

Adequate reported practices ≥ 60% (≥ 10.2 grads).

Inadequate reported practices < 60% (< 10.2 grads).

Tool III: patients' attitude toward artificial pancreas

It was designed by the researchers after reviewing related recent literatures **Hafez, et al., (2024), Wang et al., (2023),** and **Riddell & Perkins, (2022),** It included 12 questions, as the following, believe that artificial pancreas can significantly improve blood sugar control, comfortable with the idea of using a device that continuously monitors my glucose levels and automatically adjusts insulin delivery, believe the artificial pancreas reduce the burden of managing , diabetes compared to conventional insulin therapy, feel confident that the artificial pancreas will enhance quality of life by reducing the frequency of severe hypoglycemic events, trust that the artificial pancreas improve overall diabetes management and help in avoid complications, concerned about the reliability of the artificial pancreas, especially in emergencies like device failure or malfunction, think artificial pancreas should be available to all individuals with type 1 diabetes as soon as possible, prefer to use artificial pancreas if it could avoid the constant need for blood glucose testing ,would be willing to undergo training to learn how to use artificial pancreas effectively, believe that the artificial pancreas make it easier for me to live with type 1 diabetes, allowing more freedom in daily activities, and optimistic about the positive impact of the artificial pancreas on diabetes treatment.

Scoring system: for assessing patients' attitudes about artificial pancreas, "Agree" was equal 3 grades, "Neutral" was equal 2 and "Disagree" was equal 1 grade. Total scores were 12 for 36 grades. The score of items was stumped up and then converted into a percentage grade.

- **Positive attitude** ≥ 60% (≥ 21.6 scores)
- **Negative attitude** < 60% (< 21.6 scores)

Validity:

To assess the content validity of the tools, a panel of five experts from Medical Surgical Nursing (3) and Community Health Nursing (2), Faculty of Nursing, reviewed the tools for clarity, relevance, comprehensiveness, understanding, and applicability.

Reliability:

Reliability of tools was tested to determine the extent to which the questionnaire items related to each other. Cronbach's Alpha in this study was found to be 0.91 for knowledge, 0.89 for attitude and 0.88 for reported practices.

Ethical consideration:

Official approval was obtained from the Research Ethics Committee of the Faculty of Nursing at Helwan University on 29/3/2023, session number (33). Then, it was sent to the director of the mentioned hospital. The researchers explained the purpose and benefits of this study to the patients who agreed to participate in the study. Formal consent was obtained from patients before data collection. Patients were assured that all the collected data would be used for research purposes only. Participants' anonymity, confidentiality,

privacy, safety, and protection were secured.

Pilot study:

The pilot study was done on 10 % (27 patients) of the total sample to examine the clarity of the questions and time needed to complete the study tools, no modifications were made, and the pilot study was included in the study sample.

Operational design

Preparatory phase:

It included reviewing past, current, national, and international related literature and theoretical knowledge of various aspects of the study using books, articles, the internet, periodicals, and magazines to develop tools for data collection.

Fieldwork:

Data collection was started and completed within 9 months from the beginning of February (2024) until the end of October (2024), data are collected by the researchers over two days per week during morning shift in the outpatient clinic at national diabetes and Endocrinology Institute. Procedure for the study carried out through the following phases:

Construction of a structured educational program about artificial pancreas:

The study was achieved through four phases, namely assessment, planning, implementation and evaluation.

Assessment phase: The aim of this phase was to collect patients' data regarding the artificial pancreas. Each patient recruited in the study was interviewed and asked about socio-demographic data, past and present history, knowledge questionnaire, reported practices and attitude about artificial pancreas.

Planning phase: A Structured educational program was developed based on the results of the assessment and in light of related literature. The program was designed to improve knowledge, reported practices and attitude of studied patients. The structured educational program was designed based on a review of relevant literature and patients' needs identified in the pre-test. The knowledge regarding artificial pancreas comprised definition of type 1 diabetes mellitus, symptoms, function of pancreas, meaning of artificial pancreas, indications, mechanism of function , persons more needed for artificial pancreas, benefits and barrier faced in using artificial pancreas, different types of insulin use in artificial pancreas, complications of artificial pancreas, role of insulin pump in artificial pancreas, important of follow up for insulin pump of artificial pancreas ,ways of travel care for artificial pancreas during travel, exercises and during taking shower. Also, patients' attitudes and reported practices regarding dealing with artificial pancreas.

Implementation phase: The researchers implemented a structured educational program followed by the immediate post-test. The total number of patients was 274 students and divided into 10 groups; each group consisted of 28 students. Each group attends 5 sessions, two sessions per week, each session lasting 30-45 minutes which contain the following:

- Session 1: This session was concerned with the open discussion for identification, integration of group, clarification of the aim and the timetable allowed for the educational program. The researchers apply brainstorming about the meaning of type 1 diabetes mellitus, symptoms and the function of the pancreas.
- Session 2: This session was concerned with a lecture about the meaning of artificial pancreas, indications, the mechanism of function, persons more need to use artificial pancreas, benefits and barriers faced in using artificial pancreas and different types of insulin use in artificial pancreas.
- **Session 3**: The researchers' revision about the previous session, then stressed about complications of artificial pancreas, the role of insulin pump in artificial pancreas, the important of follow-up for insulin pump of artificial pancreas, ways of travel care for artificial pancreas during travel, exercises and during taking a shower.
- **Session 4:** At the starting of this session the researchers review the knowledge provided at the previous session, then explain the following; reported practices regarding dealing with artificial pancreas as general practices and insulin distribution and glucose control
- **Session 5** is concerned with practices toward

device maintenance and troubleshooting.

These sessions were achieved through several teaching methods as brainstorming, lecture, discussion and an illustrated booklet offered to every patient as a reference.

The researchers use of illustrative media; computer, video, and pictures. At the end of each session there is a time for asking questions and feedback.

Evaluation phase: Evaluation of the structured educational program for patients was done immediately after implementation of the program through using the same tools of pre-test as post-test.

Administrative Design:

An official letter requesting permission to conduct the study was directed by the dean of the Faculty of Nursing at Helwan University to the directors of the National Diabetes and Endocrinology Institute to obtain their approval to carry out this study.

Statistical design:

The collected data were coded and entered into a Social Science Statistical Package (SPSS Version 29.00) and ANOVA test. For categorical variables, descriptive statistics were used in the form of frequencies and percentages, whereas for continuous quantitative variables, means and standard deviations were used. The Chi-square (X^2) test was used to compare qualitative category data, with the hypothesis that the row and column variables are independent, but without revealing the degree or direction of the link. The T-test was used to compare qualitative variables and the person correlation coefficient (r) was used for correlation analysis.

The degree of significance of results was identified at:

- The significant result when the P-value < 0.05.
- The highly significant result when the P-value < 0.001.
- The non-significant result when the P-value > 0.05.

Results:

Table (1): Shows that, 54.7 % of the studied patients their age ranged between 20-< 30 years with the mean age were 29.4 ± 3.7 years, 83.9% of them were married and 60.6 % of them were male. 69.7% of studied patients had university education, 55.5 % of them were employees and 43.8 % of them had family income was enough for basic needs. Moreover 64.6 % of the studied patients were resident in urban area.

Table (2): Demonstrates that, 73.0% of the studied patients had family history of diabetes, and 38.7% of them duration of diabetes was from 6 to 10 years. While, 45.3 % of them had complications of diabetic as cardiovascular disease. 52.6% of the studied patients take Insulin therapy as type of medication or therapy currently using to manage diabetes. In addition, 41.6 % of them had several times a week to monitor blood glucose levels and 50.4 % of them taken other medication.

Figure (1): Illustrates that, 82.7 % of studied patients had good total knowledge at post structured educational program while 8.2% of them had good knowledge at preprogram. 5.9 % of studied patients had poor knowledge at post structured education program while 74.5% of them had poor knowledge at pre-program.

Figure (2): Illustrates that, 76.6 % of studied patients had inadequate total reported practices pre implementing structured educational program. While 84.7 % of studied patients had adequate total reported practices post implement of structured educational program about artificial pancreas.

Table (3): Indicates that, there was highly statistically significant positive correlation between total knowledge score and total reported practices score (r= 0.775, p=0.000). Also, there was highly statistically significant negative correlation between total knowledge score and total attitude score (r= -0.884-, p=0.000). Moreover, there was highly statistically significant negative correlation between total reported practices score and total attitude score (r= -0.872-, p=0.000).

Table (4): Reveals that, the presence of a highly significant model, as indicated by the F-test result of 57.41 with a p-value of 0.000. This model explains 73.7% of the variation in total knowledge regarding artificial pancreas, with an R-squared value of 0.737. Furthermore, it demonstrates that the domain of education level at B 1.753 and Beta 0.459, monthly income domain B -1.522- and Beta

-0.256-, age domain B 1.236 and Beta 0.148 and occupation domain B -1.230- and Beta -0.127-; while marital status doesn't predict total knowledge score with a p-value of >0.05.

Table (5): Reveals that, the presence of a highly significant model, as indicated by the F-test result of 53.94 with a p-value of 0.000. This model explains 72.5% of the variation in total reported practices regarding artificial Pancreas, with an R-squared value of 0.725. Furthermore, it demonstrates that the domain of total knowledge score had a strong predictor of total reported practices score with B 0.355 and Beta 0.518, followed by education level at B 0.876 and Beta 0.335, marital status domain B -0.731- and Beta -0.150- with a p-value of <0.01. Also, occupation domain had a moderate predictor of total reported practices score with B 0.707 and Beta 0.107 with a p-value of <0.05; while age and monthly income doesn't predict total reported practices score with a p-value of >0.05.

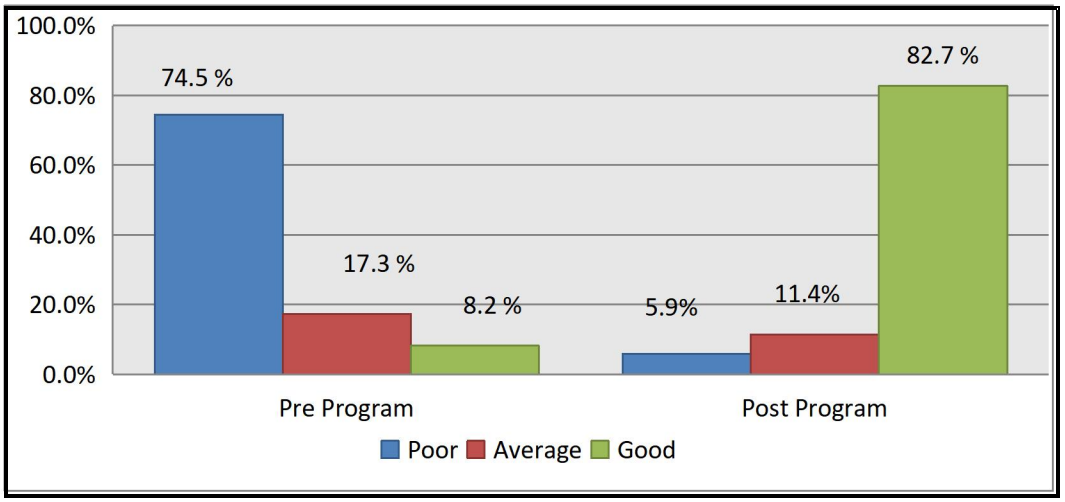
Table (6): Shows that, the presence of a highly significant model, as indicated by the F-test result of 135.29 with a p-value of 0.000. This model explains 88.6% of the variation in total attitude score about artificial pancreas, with an R-squared value of 0.886. Also, it reveals that the domain of total reported practice score had a strong predictor of total attitude score about artificial pancreas with B -0.767- and Beta -0.418-, followed by total knowledge score at B -0.493- and Beta -0.392-, monthly income domain B 0.884 and Beta 0.118 with a p-value of <0.01; while age, marital status, education level and occupation doesn't predict total attitude score about artificial pancreas with a p-value of >0.05.

Table (1): Frequency Distribution of the Studied Patients' Socio-demographic Characteristics (n=274).

Socio-demographic Characteristics	No.	%
Patient's age (Years)		
20- < 30	150	**54.7**
30 - <40	60	21.9
40-< 50	42	15.3
50- 60	22	8.1
Mean ± SD 29.4 ± 3.7 years		
Sex		
Male	166	**60.6**
Female	108	39.4
Marital status		
Married	230	**83.9**
Divorced	20	7.3
Widowed	24	8.8
Level of education		
Read and write	55	20.2
Basic education	10	3.6
Secondary education	13	4.7
University education	191	**69.7**
Postgraduate	5	1.8
Occupation		
Employee	152	**55.5**
Non-employee	122	44.5
Family income		
Not enough for basic needs	80	29.2
Enough for basic needs	120	**43.8**
Enough and saved	74	27.0
Place of residence		
Urban	177	**64.6**
Rural	97	35.4

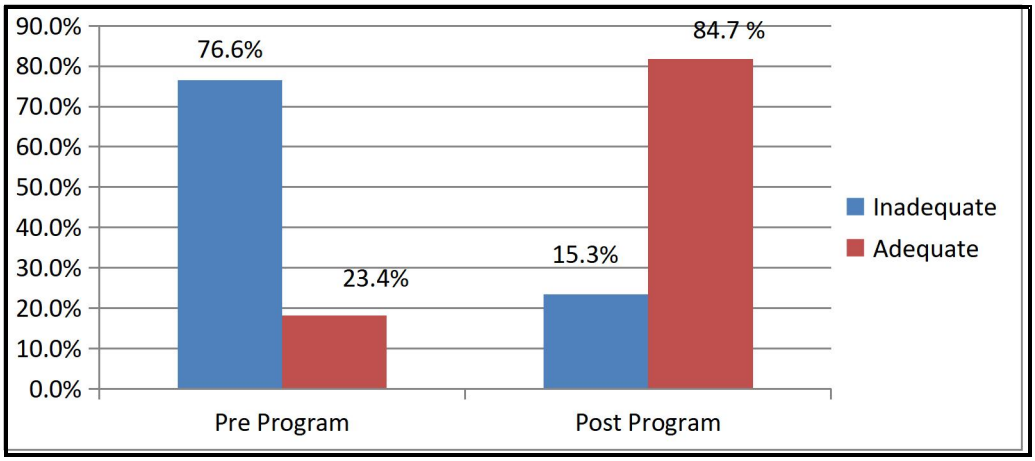
Table (2): Frequency Distribution of Studied Patients' according to Past and Current Medical History (n =274).

Past Medical History	No.	%
Family history of diabetes		
Yes	200	**73.0**
No	74	27.0
In case of yes, what is their relationship (n=200)		
Mother	135	**67.5**
Father	55	27.5
Sibling	10	5.0
Duration of Diabetes		
> 1 year	25	9.2
1-5 years	90	32.8
6-10 years	106	**38.7**
>10 years	53	19.3
Complications from diabetic		
Diabetic retinopathy	50	18.2
Diabetic neuropathy	100	36.5
Cardiovascular disease	124	**45.3**
Have been hospitalized due to diabetes-related complications in the past year		
Yes	115	42.0
No	159	**58.0**
Current Medical History		
Type of medication or therapy are currently using to manage diabetes		
Oral hypoglycemic agents	70	25.5
Insulin therapy	144	**52.6**
Diet and exercise only	60	21.9
Times for monitor blood glucose levels		
Multiple times a day	80	29.2
Once a day	80	29.2
Several times a week	114	**41.6**
Have taken any other medication		
Yes	138	**50.4**
No	136	49.6
If yes, what's types of medication used (n=138)		
Antihypertensive medications	55	39.9
Cholesterol-lowering agents	60	**43.5**
Aspirin or other blood thinners	23	16.6



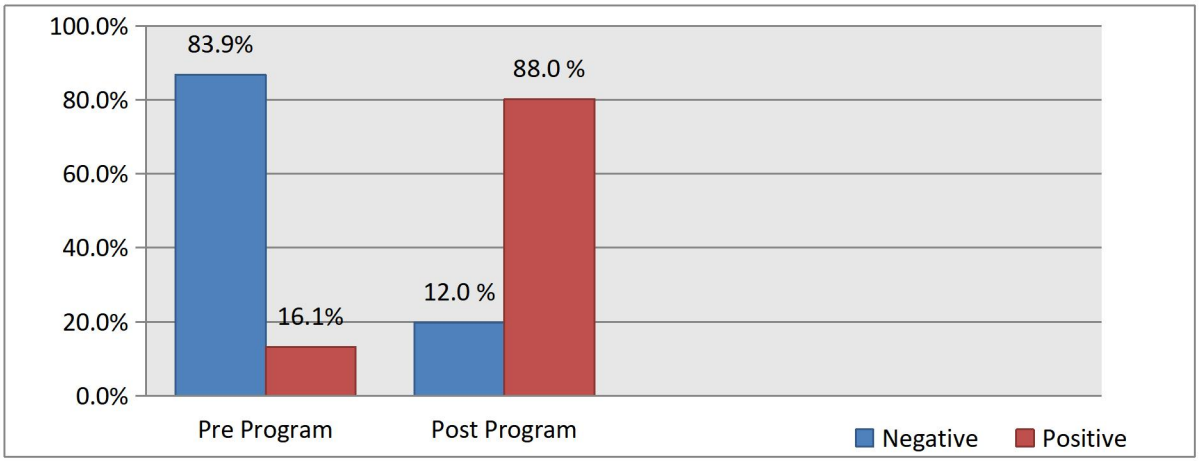
χ^2= 40.740 P value=0.004*

Figure (1): Percentage Distribution of Total Knowledge among Studied Patients regarding Artificial Pancreas Pre & Post Structured Educational Program (n=274).



χ2= 59.867 P value =<0.001

Figure (2): Percentage Distribution of Studied Patients' Total Reported Practices about Artificial Pancreas Pre and Post Structured Educational Program (n=274).



χ2= 64.454 P value = <0.001

Figure (3): Percentage Distribution of Studied Patients' Total Attitude regarding

Artificial Pancreas Pre and Post Structured Educational Program (n=274).

Table (3): Correlation between Studied Patients' Total Knowledge score, Total Reported Practices and Total Attitude Regarding Artificial Pancreas Pre and Post Structured Educational Program (n=274).

Variables		Post Structured Educational Program	
		Total knowledge score	Total reported practices score
Total knowledge score	**r** **P**	**1**	0.775 0.000**
Total reported practices score	**R** **P**	0.775 0.000**	**1**
Total Attitude score	**R** **P**	-0.884- 0.000**	-0.872- 0.000**

R= Pearson correlation coefficient test**. P=** p-value**. (-) =** negative correlation**.**
**Highly statistically significant at p ‹ 0.01.
Interpretation of r: **Weak** (0.1-0.24) **Intermediate** (0.25-0.74) **Strong** (0.75-0.99) **Perfect** (1).

Table (4): Multiple Linear Regression Model of Studied Patients Knowledge regarding Artificial Pancreas Post Structured Educational Program (n=274).

Items	Unstandardized Coefficients		Standardized Coefficients	T	P. value
	B	**Std. Error**	**Beta**		
Constant	-0.137-	2.263		-0.061-	0.952
Age	1.236	0.446	0.148	2.774	0.006**
Marital status	0.290	0.366	0.041	0.793	0.430
Education level	1.753	0.302	0.459	5.799	0.000**
Monthly income	-1.522-	0.312	-0.256-	-4.885-	0.000**
Occupation	-1.230-	0.456	-0.127-	-2.701-	0.008**
Model Summary					
Model	**R**		**R^2**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.858		0.737	0.724	2.791
ANOVA					
Model	**Df**		**F**		**P. value**
Regression	6		57.412		0.000**

a. Dependent Variable: Total knowledge score**.**
b. Predictors: (constant): Age, Marital status, Education level, Monthly income, and occupation.
F= One Way ANOVA Test**. t:** Independent t-test**. *Significant at p ‹ 0.05. **highly significant at p ‹ 0.01.**
df = degree of freedom. **R^2** = Coefficient of multiple determination.

Table (5): Multiple Linear Regression Model for Studied Patients reported Practices regarding Artificial Pancreas Post Structured Educational Program (n=274).

Items	Unstandardized Coefficients		Standardized Coefficients	T	P. value
	B	Std. Error	Beta		
Constant	4.093	1.471		2.782	0.006**
Age	-0.450-	0.321	-0.079-	-1.400-	0.164
Marital status	-0.731-	0.249	-0.150-	-2.935-	0.004**
Education level	0.876	0.227	0.335	3.856	0.000**
Monthly income	0.331	0.233	0.081	1.421	0.158
Occupation	0.707	0.328	0.107	2.152	0.033*
Total knowledge score	0.355	0.057	0.518	6.217	0.000**

Model Summary				
Model	**R**	**R^2**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.851	0.725	0.711	1.956

ANOVA			
Model	**Df**	**F**	**P. value**
Regression	6	53.946	0.000**

a. Dependent Variable: Total reported practices score**.**
b. Predictors: (constant): Age, Marital status, Education level, Monthly income, Occupation and Total knowledge score.
F= One Way ANOVA Test**. t:** Independent t-test**. *Significant at p ‹ 0.05. **highly significant at p ‹ 0.01.**
df = degree of freedom. **R^2** = Coefficient of multiple determination.

Table (6): Multiple Linear Regression Model of Total Attitude of Studied Patients Regarding Artificial Pancreas Post Structured Educational Program (n=274).

Items	Unstandardized Coefficients		Standardized Coefficients	T	P. value
	B	Std. Error	Beta		
Constant	32.636	1.797		18.157	0.000**
Age	-0.048-	0.384	-0.005-	-0.125-	0.901
Marital status	0.396	0.305	0.044	1.296	0.198
Education level	-0.553-	0.285	-0.115-	-1.940-	0.055
Monthly income	0.884	0.279	0.118	3.172	0.002**
Occupation	0.257	0.396	0.021	0.647	0.519
Total knowledge score	-0.493-	0.078	-0.392-	-6.352-	0.000**
Total reported practices score	-0.767-	0.107	-0.418-	-7.175-	0.000**

Model Summary				
Model	**R**	**R^2**	**Adjusted R Square**	**Std. Error of the Estimate**
1	0.941	0.886	0.879	2.318

ANOVA			
Model	**Df**	**F**	**P. value**
Regression	7	135.29	0.000**

a. Dependent Variable: Total attitude of patients regarding artificial pancreas score**.**
b. Predictors: (constant): Age, Marital status, Education level, Monthly income, Occupation, Total knowledge score and Total reported practice score.
F= One Way ANOVA Test**. t:** Independent t-test**. *Significant at p ‹ 0.05. **highly significant at p ‹ 0.01.**
df = degree of freedom. **R^2** = Coefficient of multiple determination.

Discussion:

An artificial pancreas is a medical device system designed to help patients with Type 1 Diabetes Mellitus (T1DM). It monitors blood glucose levels and delivers insulin automatically. The system typically includes a Continuous Glucose Monitor (CGM), an insulin pump, and a control algorithm. The CGM tracks glucose in real time. The control algorithm calculates the needed insulin dose. The insulin pump then delivers the dose without manual input. This reduces the risk of both hyperglycemia and hypoglycemia. It improves overall glucose control. Artificial pancreas systems aim to mimic the function of a healthy pancreas. They improve the quality of life for T1DM patients ***(Tauschmann & Hovorka, 2023).***

Concerning socio-demographic characteristics The result of present study showed that more than half of the studied patients were in the age group of 20-<30 years with mean age was 29.4±3.7 years, more than three fifths of them were male, majority of them were married, more than two thirds of them had university education, more than half of them were employee, more than two fifths of them had the family income was enough for basic needs and less than two thirds of them lived in urban. This result was consistent with the results of study performed by **Oukes et al., (2022)** in Twente, Holland (n=425), in their study titled "Acceptance of the Artificial Pancreas: Comparing the Effect of Technology Readiness, Product Characteristics, and Social Influence Between Invited and Self-Selected Respondents" and found that 55.2 % of participants were in the age group of 20-<30, 60.8% of them were male and 69.7%of them had university education. Also, these findings were in agreement with **Okafor et al., (2023)** who conducted a study in Nigeria (n=382) entitled "Effect of educational intervention program on self-efficacy of individuals with type 2 diabetes mellitus" and clarified that, majority of the sample were married and 64.2% of them lived in urban. From the researchers' point of view, these results are due to the culture and state's interest in education, which led to the presence of more than two-thirds of the studied patients having university education and married.

Also, Type 1 diabetes often starts at a young age because it is an autoimmune condition where the body attacks its own insulin-producing cells, and this process typically begins early in life due to a combination of genetic susceptibility and environmental triggers.

Regarding the past medical history of studied patients, the current result showed that less than three-quarters of them had a family history of diabetes, less than two-fifths of them duration of diabetes was from 6 to 10 years and less than half of them had cardiovascular disease as complications from diabetes. Regarding current medical history, more than half of the patients studied patients taking insulin therapy to manage diabetes and more than two-fifths of them monitored their blood glucose level several times a week.

These study results were supported by **Wanwisa et al., (2025).** whose conducted study in Thailand (n=70) in their recent study titled "Effects of the Holistic Self-Care Program on Diabetes among Diabetic Mellitus Patients in a Rural Area of Sakaeo Province, Thailand" And found that 59.6 % of studied sample had family history of diabetes, 35.7% of them duration of diabetes was from 6-10 years, 28.6% had complications and majority of them taken insulin therapy for treatment of diabetes. From the researchers' point of view, due to in type1 diabetic mellitus there is autoimmune destruction of pancreatic β-cells lead absolute insulin deficiency which the body cannot produce insulin and requires lifelong insulin therapy. Also, these types of diabetes are mainly genetic.

Related to the studied patients' total knowledge level about artificial pancreas pre/post Structured Educational Program; the current study results revealed that majority of the studied patients had good knowledge post structured educational program while minority of them had good knowledge preprogram, less than three quarters of them had poor knowledge at preprogram while minority of them had poor at post knowledge preprogram with highly statistical significant differences between level of patients knowledge pre/post program.

This result was congruent with **Mohamed et al., (2024)** in Egypt (n=100) entitled "Effect of Educational Guidelines on Diabetic Patients' Knowledge, Attitude, and Self-Efficacy Regarding Use of Artificial Pancreas", and reported highlighted that a significant difference in

the satisfactory knowledge level of patients from 15% pre-educational guidelines to 57% post-educational guidelines. While, these This result was inconsistent with the result of study performed by **Hafez et al., (2024)** In Egypt (n=385) in their recent study entitled " The Path from Awareness to Action: Exploring Diabetic Patients' Awareness and Attitudes and Barriers to Utilization of Artificial Pancreas in the Beheira Governorate, Egypt" and reported that 61% of the participants had a satisfactory level of overall knowledge regarding the artificial pancreas.

From the researchers' point of view, the improvement of knowledge at post structured educational program could be related to more than two-thirds of the studied patients ware university education lead understanding items of the program content in the sessions. As well, this may be attributed to patients' desire to seek information to increase their awareness about their condition and effectiveness of the program.

Regarding the total level of reported practices among studied patients about artificial pancreas pre/post structured educational program. The current study illustrated that more than three-quarters of the studied patients had an inadequate level of reported practices pre-implementing a structured educational program while markedly improved to the majority of them had adequate level of reported practices at post.

These results were in the same line with **Lim & Kim, (2023) who** conducted a study in Korea (n=20) in their recent study titled "A practical approach based on learning-based model predictive control with minimal prior knowledge of patients for artificial pancreas" and clarified improvements in practices after learning-based model predictive control.

From the researchers' point of view, this result could be related to the improvement in knowledge of studied patients leading to enhancements in practices at post program while before the program, the patients need for raising their awareness and training to gain more experience about right uses of artificial pancreas.

Concerning total attitude among studied patients regarding the use of artificial pancreas pre-post structured educational program, the present study results, illustrated that at pre structured educational program, more than four-fifths of studied patients had a negative attitude while at post majority of them had a positive attitude.

This result was in agreement with **Mohamed et al., (2024)** who mentioned that significant differences in the total level of positive attitude increased from 22.0% pre-educational guidelines to 63.0% post-guidelines, and there was improvement in attitudes regarding using an artificial pancreas. Also, these study results were in the same line with **Hafez et al., (2024**) and reported that more than two-thirds of participants had a positive attitude toward artificial pancreas.

From the researchers' point of view, these results may be due to increase studied patients' awareness about benefits of artificial pancreas in reducing the need for frequent finger-prick tests and manual insulin dosing, makes it easier to manage diabetes during exercise, meals, and daily activities, reduces both hyperglycemic and hypoglycemic episodes by delivering more precise insulin doses in real-time and improve their quality of life.

Concerned with the correlation between total knowledge, attitude and reported practices of studied patients post structured education program, the current study showed that a highly significant positive correlation between studied patients' total knowledge, total attitude and total reported practices about artificial pancreas.

This current result agree with the study of **Asmelash et al.,(2022)** titled "Knowledge, Attitude, and Practice towards Glycemic Control and Its Associated Factors among Diabetes Mellitus Patients' In multivariate logistic regression, were significantly associated with knowledge towards glycemic control of diabetes, and in multivariable logistic analysis, were significantly associated with the attitude of participants towards glycemic controls of diabetes and practices towards glycemic controls. These results may be due to the effectiveness of a structured educational program about artificial pancreas.

Regarding to multiple linear regression model of studied patients knowledge regarding artificial pancreas post structured educational program, the study results showed that the presence of a highly significant model, as indicated by the F-test result of 57.41 with a p-value of 0.000and their all items of socio-demographic characteristics and show the male under study had knowledge than female and regarding post graduate education level patients had good knowledge post implementation of structured education program.

These results disagree with the result of

Al-**Wagdi and Al-Hanawi (2024)** entitled "Knowledge, attitude and practice toward diabetes among the public in the Kingdom of Saudi Arabia: a cross-sectional study "has identified that males exhibit lower knowledge about diabetes compared to females. This could be attributed to the fact that women with higher knowledge about diabetes are selected in the sample. Moreover, there exists a direct correlation between higher levels of education and income and enhanced knowledge and practices related to diabetes. From the researchers' point of view, this result may be due to most of the study sample were men

Concerning the multiple linear regression model for studied patients reported practices regarding artificial pancreas post-structured educational program, the study results showed that there the presence of a highly significant model, as indicated by the F-test result of 53.94 with a p-value of 0.000 and all items of socio-demographic characteristics. These results were agreement with **Lim & Kim, (2023)** and illustrated that the presence of a highly significant model, as indicated by the F-test result of 53.94 with a p-value of 0.000 and their items of demographic characteristics after A practical approach based on a learning-based model.

Regarding the multiple linear regression model of total attitude of studied patients regarding the artificial pancreas post-structured educational program and their all items of socio-demographic characteristics. This result was supported by **Mohamed et al., (2024)** who reported that the presence of a highly significant model, as indicated by the F-test result of 135.29 with a p-value of 0.000 about artificial pancreas at post educational guidelines and items of demographic characteristics.

Conclusion:

In light of the present study findings, there were statistically significant improvements in post-program than pre-program regarding patients' knowledge, reported practices and attitude about artificial pancreas.

Recommendations:

Based on the findings of the study, the following recommendations are suggested:

- Raise awareness among patients by health education to increase their knowledge, attitude and practices regarding artificial pancreas.
- Training patients about practices regarding artificial pancreas to increase self-confidence and improve management of diabetes.
- Simple pamphlets and posters about artificial pancreas should be provided for diabetic patients in outpatient clinics.
- Further research on a larger sample and in other settings is needed.

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